SLAG—IRON AND STEEL

By Hendrik G. van Oss

In the making of crude or pig iron in a blast furnace, iron oxide ores are stripped of oxygen and other impurities by means of high-temperature reactions with carbon reducing agents and fluxes. Most of the impurities and fluxing agents combine to form a liquid silicate melt called iron or blast furnace slag, which floats above the liquid crude iron and which is tapped (removed) from the blast furnace separately from the iron. The crude iron is then transferred to a steel furnace, where the iron's residual carbon content of about 4% is reduced, generally to below 0.5%, and other impurities are removed; this process involves lime and silicate fluxes and the formation of steel slag. Steel furnaces, particularly electric arc furnaces (EAF), also may be fed with scrap iron and steel, but again the impurities are removed by fluxing agents that form a slag. Apart from the original furnace feedstock impurities, slags (especially steel slags) also may contain significant amounts of entrained free metal. The physical attributes of slags when solidified—glassy, metallic, or stony; hard and compact or vesicular—depend mainly on how the material was cooled. The cooling method also largely determines how a particular slag may be used.

Slags have been used for construction purposes, especially for road surfaces, since Roman times, but with the advent of the industrial revolution, iron and steel production rose dramatically, and the volume of slag produced soon far outpaced consumption of slag. The result was a growth of unattractive slag piles on industrial land. By the mid-19th century, new uses for slags had been found, particularly as an aggregate in hydraulic cement concrete and, for some slags, as a cementitious material in its own right. Consumption remained modest, however, until the 20th century, when slag was found to be an excellent aggregate for asphaltic concrete (asphalt) road paving. This and other new uses, together with a rapidly increased use of hydraulic cement concrete worldwide, led to the consumption of most existing slag piles and current slag consumption roughly keeps pace with new slag production. Ferrous slags are now properly recognized as useful coproducts of the iron and steel industry, not waste products.

Notwithstanding their utility, most slags have very low unit values compared to pig iron and steel products. Iron and steel companies, accordingly, consider the slag they produce to be a nuisance and contract with outside slag processing companies to get rid of it; the slag processing company may also be responsible for cooling the slag. Although the financial arrangements vary, typically the processing company receives the cooled slag for free, crushes it to various marketable sizes, uses screens and magnetic separators to recover entrained metal from the slag (this metal to be returned to the furnace for a low charge), sells the slag on the open market, and pays a small percentage of the net slag sales revenues or profits to the iron or steel company.

Blast furnace slags are of three main types. The first, air-cooled blast furnace slag, is formed by allowing the molten slag to cool relatively slowly under ambient conditions; final cooling can be accelerated with a water spray. The cooled material is hard and dense, although it can have a vesicular texture with closed pores. After crushing and screening, air-cooled slag is used mainly as an aggregate for road metal, road bases and fill, concrete, asphalt paving, and railway ballast.

The second type, expanded or foamed slag, is cooled through a water jet, which leads to rapid steam generation and the development of innumerable vesicles within the slag. The vesicular texture reduces the overall density of the slag, and allows for good mechanical binding with hydraulic cement paste. Expanded slag is primarily used for lightweight concrete aggregate.

The third type, granulated slag, is formed by quenching molten slag in water. The very rapid cooling causes solidification of the slag as sand-sized particles of glass. The disordered structure of this glass gives the material moderate hydraulic cementitious properties when very finely ground (finer than most grades of portland cement), but if it can access free lime, the ground granulated blast furnace slag (GGBFS) develops strong hydraulic cementitious properties. There is a ready market for GGBFS as a partial substitute for portland cement in concrete mixes or mixed with portland cement to make finished blended cement. In both applications, the hydration of the portland cement releases the lime needed to activate the GGBFS. Concrete containing GGBFS and portland cement generally develops strength more slowly than concretes containing only portland cement, but can have similar or even superior long-term strength, release less heat during hydration, and show improved resistance to chemical attack. Where the chemistry of granulated blast furnace slag is unsuitable, or the material has been inadequately quenched, or the slag is weathered (old slag piles), the slag may lack cementitious properties but can still be used as a fine-grained aggregate.

Blast furnace slag (generally air-cooled) also can be made into mineral wool. Slag for this purpose is remelted and then poured through an air stream or jet of steam or other gas to produce a spray of molten droplets; alternatively, the droplets can be formed by passing the melt through a perforated or fast spinning disc. The droplets elongate into long fibers that are collected and layered. Mineral wool is mainly used for thermal insulation.

Steel furnace slag is cooled similarly to air-cooled blast furnace slag, has similar properties to it, and is used for many of the same purposes. To some degree, the properties of steel slags vary depending on the type of furnace that generated them. Basic oxygen furnaces principally refine crude iron into steel, whereas EAFs are mainly used to remelt steel scrap. Steel slags containing large amounts of dicalcium silicate are prone to expansion and commonly are cured in piles for some months to allow for this and for leaching of lime. If sold uncured, steel slags may not be appropriate for uses where a fixed product volume must be sustained. Free-lime-bearing steel slags can find limited application as a soil conditioner. Although all slags can be used as raw materials for cement (clinker) manufacture (where they supply part of the requisite aluminum, calcium, iron, and silicon oxides), steel slags have proven to be especially suitable for this use.

Data in this report are based on an annual U.S. Geological Survey (USGS) canvass of slag processors and relate to sales of processed slag rather than to the amount of slag processed by the same firms or to the actual production of slag by iron and steel companies. Processed slag is sold from stockpiles, and although most of the material is a byproduct of current or recent iron and steel production, some of the slag is material mined from old slag piles (slag banks) representing iron and steel production sites long since closed.

Tracking the slag processing industry is complicated by a number of factors. A given production site can be serviced by more than one slag processing company, each handling a specific type of slag. This processing may be handled at different sites from the onset, or material may be initially handled by one company and then transferred to another for final processing at another location (for example, granulated slag produced in East Chicago, IN, may be ground in South Chicago, IL). These and other factors can lead to a proliferation of names for one site. Processing contracts can change hands among slag companies, usually as a result of competitive bidding or ownership consolidation in the slag processing industry but also from changes in ownership of the iron and steel companies or from changes in demand for a given type of slag. Loss of processing contracts, closures of iron and steel plants, and the exhaustion of old slag piles may become known to the USGS only indirectly through the nonreceipt of a specific survey form, the indication of no production or sales on a returned form, or perhaps guidance in the form of the words "closed" or "contract lost." Likewise, the gain of a processing contract may be revealed by the voluntary inclusion of a "new" site by a slag company, but often this is without guidance as to the identity of the previous processor (if any).

In 2002, questionnaires or followup inquiries were sent to 23 processing companies, covering 125 processing sites, and some form of response (basic tonnages primarily) was received for all but 6 sites. The reported tonnages account for about 93% of the total slag tonnage shown in table 1.

In terms of overall tonnages and values, there was a much higher component of estimation in the 2001 and earlier surveys than in the 2002 survey. Accordingly, the 2001 data have been omitted from the tables in the current report, although they remain available on the USGS Web site in previous editions of the annual report. Any comparison of 2002 data to earlier data should be made with caution. Although the national totals data in the 2002 survey are believed to be more accurate and complete than those of recent past surveys, the 2002 data remain inadequate to show meaningful tonnage splits of different slags by type of use or overall by type of transportation. Accordingly, the data tables in the current report have been simplified and reduced to just two. The current tables, however, do have a couple of significant improvements compared with earlier reporting. First, the data on sales of granulated slag are now far more complete and can be revealed, as opposed to being combined with expanded slag as in previous reports (tables 1, 2). Second, the tabulation of slag processors and processing sites has been augmented with the names of the iron and steel companies being serviced at each site (table 3).

Legislation and Government Programs

Demand for slag in the construction sector is affected by State and Federal programs that affect construction spending levels. The main Federal funding program of this type continued to be the Transportation Equity Act for the 21st Century (TEA-21), but the effects of TEA-21 on slag consumption levels have been muted, and some projects partially funded under this act have been delayed owing to States having difficulty in cofunding the projects.

Most of the environmental issues (chiefly of emissions) associated with iron and steel manufacture tend to focus on the metal products and not on the slag. Slag piles, however, can be a source of contaminated leachate, and although this can be an incentive for State Governments to specify the use of slag in construction projects (to consume the slag piles), it has also allowed public opposition to the use of slag in some projects on environmental grounds.

Production

Although production metallurgists and chemists at iron and steel plants commonly can quote the amount of slag in the blast furnace or steel furnace at any particular time, it is rare for plant personnel to know how much slag is actually produced over an extended series of production cycles (heats). This is because, generally, not all the slag is tapped during a heat, and the amount of slag tapped is not routinely measured. Accordingly, there are no data on U.S. production of ferrous slag, and few, if any, data on foreign production, although both can be estimated.

The amount of slag produced is largely determined by the overall chemistry of the raw material charges to the furnaces. For a blast furnace, the chief determinant is the overall grade of the iron ore. For an ore feed grading 60% to 66% iron, about 0.25 to 0.30 ton of blast furnace slag will be produced per ton of crude iron. Lower grade ores yield more slag—sometimes as much as 1.0 to 1.2 tons of slag per ton of crude iron. Steel slag output is also variable and depends on both the feed chemistry and the type of furnace used, but is typically about 0.2 ton of slag per ton of crude steel. However, up to 50% of the molten steel slag is entrained metal, most of which is generally recovered during slag processing and returned to the furnace. Thus the amount of marketable slag remaining after entrained steel removal is usually equivalent to about 10% to 15% of the crude steel output. Using these ratios and USGS data for U.S. and world iron and steel production, it is estimated that U.S. blast furnace slag production in 2002 was in the range of 10 to 12 million metric tons (Mt), and world output was in the range of 150 to 180 Mt. Likewise, U.S. output of steel slag (after metal removal) is estimated to be 9 to 14 Mt, and world output, 90 to 135 Mt.

Consumption

Although slag production is proportional to iron and steel output, the correlation of either with slag sales (consumption) is only approximate. This is because slags may need to be cured for extended periods prior to sale, and it is common for slag processors to accumulate processed slag stockpiles either because of slow sales or in order to be able to bid on large construction projects. Most forms of processed slags have low unit values and thus generally cannot be transported very far economically. Slag sales are thus highly dependent on local construction demand and on competition from natural aggregates (crushed stone, sand and gravel).

Sales of air-cooled slag totaled about 7.4 Mt in 2002, and those of steel slag were 7.9 Mt (table 1). The value of these sales totaled about $84 million. As noted earlier, data quality issues preclude direct comparison with 2001 and earlier slag data. For example, the total sales of air-cooled slag plus steel slag in 2002 were about 0.7 Mt higher (an apparent 5% increase) than data reported in 2001. USGS survey data show that output of crushed stone and construction sand and gravel (much of which is sold for aggregate) in 2002 was slightly (1% to 2%) lower than in 2001, and USGS data for portland cement sales show an almost 4% decline in 2002. Both the natural aggregates and cement data are in accord with an overall decline of 1.7% in construction spending in 2002 [U.S. Census Bureau data quoted by the Portland Cement Association (2003)], including a 2.4% decline in spending on roads and highways. Thus the 2002 slag sales volumes likely represent a modest decline from actual sales levels in 2001.

Granulated slag is now processed by enough companies and in sufficient quantities for a national total to be published (tables 1, 2). In 2002, approximately 3.7 Mt of granulated slag was sold. About 90% of this amount was used, largely as GGBFS, for the manufacture of hydraulic cements and as a partial substitute for portland cement in concrete. The remainder was of too poor quality for such uses and was sold as fine aggregate. The USGS slag survey does not distinguish between granulated slag sold to cement companies and that sold directly to concrete companies, but the 2002 canvass of cement companies indicates that the cement producers only consumed 0.3 Mt of granulated slag during the year. The consumed material was primarily GGBFS for blended and masonry cements, but some unground material was consumed as a grinding aid for making portland cement. This information alone indicates that the concrete companies are the major customers. Sales of GGBFS under the name “slag cement” are promoted by the Slag Cement Association, whose members account for most U.S. production of this material. The Association’s Web site indicates that sales of GGBFS in 2002 amounted to 2.9 Mt, which is in close agreement with the USGS data. Granulated slag is an important component of the total sales of blast furnace slags because of its relatively high unit value. In unground form, granulated slag sells for about $35 per ton and sells for about twice that amount as GGBFS (table 2). This is in contrast to a range of about $3 to $14 per ton for air-cooled slag; the prices are necessarily low to allow the material to compete with natural aggregates. Granulated slag accounted for almost 80% of the value of total blast furnace slag sales. Steel slag generally sells for somewhat less than air-cooled slag, again reflecting its principal role as an aggregate.

Imports of ferrous slags are almost entirely of granulated blast furnace slag (unground). In 2002, imports of granulated slag totaled 0.86 Mt at an average unit price [cost, insurance, freight (c.i.f.)] of about $38.50 per ton. Of the 11 countries that supplied granulated slag in 2002, Italy was the largest source (45%), followed by France (28%), and Japan (8%).

Outlook

Given the robust market and high prices realized for GGBFS, it is perhaps surprising that granulators are currently installed at only five locations in the United States (two of these were installed in 2001); most of the remainder of the GGBFS was processed at about a dozen grinding plants that relied on imported unground feed. The attractiveness of installing granulators at additional blast furnace locations is mitigated by the cost to install and to build an associated grinding plant and by the precarious health of the integrated iron and steel plants. The number of blast furnaces in operation is in decline, and no new ones have been constructed in several decades. Ownership consolidation in the steel industry will not likely reverse this trend. It is more likely that additional import-based grinding plants will be constructed; one such plant was under construction in Florida. An increasing number of cement plants have converted part of their grinding circuits to slag-grinding duty.

The market for slag as an aggregate is likely to fluctuate at about current levels for a number of years. Consumption levels are threatened by shortfalls in construction spending and by delays to construction projects on environmental grounds; the latter also threaten to favor natural aggregates over slags. The availability of air-cooled slag is in slow decline owing to closures of some blast furnaces and depletion of some existing slag piles. Steel slag supply is more assured, owing to the relative abundance of EAFs. Lobbying was already underway in 2002 to provide for an extension of TEA-21 funding beyond 2004, preferably at higher levels. Government and industry efforts to promote “sustainable” construction materials and practices and recycling in general likely will favor the increased use of slags in many of their current applications.

Reference Cited

Portland Cement Association, 2003, Construction put in place: Monitor, v. 13, no. 6, June, p. 2.

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publication

Iron and Steel Slag. Ch. in Mineral Commodity Summaries, annual.

Other

National Slag Association.
Portland Cement Association.
Slag Cement Association.

TABLE 1
IRON AND STEEL SLAG SOLD OR USED IN THE UNITED STATES IN 2002

(Million metric tons and million dollars)

	Blast furnace slag[1]			Steel	Total iron
	Air-cooled	Granulated	Total[2]	furnace slag	and steel slag[2]
Quantity[3]	7.4	3.7	11.0	7.9	19.0
Value[e, 4]	55	210	265	29	294

[e]Estimated.

[1]Excludes expanded slag to protect company proprietary data. The quantity is very small (less than 0.1 unit).

[2]Data may not add to totals shown because of independent rounding.

[3]Quantities are rounded to reflect inclusion of some estimated data and to reflect inherent accuracy limitations of reported data.

[4]Values are rounded because of the inclusion of a large estimated component.

TABLE 2
SELLING PRICES FOR IRON AND STEEL SLAG
IN THE UNITED STATES IN 2002[1]

(Dollars per metric ton)

Slag type	Range	Average
Blast furnace slag:		
Air-cooled	3.35–14.04	7.39
Granulated[2]	34.86–69.47	57.25
Steel slag	0.55–10.32	3.75

[1]Data contain a very large estimated component.
[2]Range shown is for material reported for use in finished cement manufacture or as a cementitious additive in concrete. Material at the low end of the range is sold in unground form.

TABLE 3
PROCESSORS OF IRON AND STEEL SLAG IN THE UNITED STATES IN 2002

Slag processing company	Plant location	Steel company serviced[2, 3]	Slag and furnace types[1]					
			Blast furnace slag			Steel furnace slag		
			AC	GG	Exp	BOF	OHF	EAF
Allega Slag Recovery	Cayahoga, OH	International Steel Group, Inc.	X					
AMSI	Holsopple, PA	North American Höganäs						X
Beaver Valley Slag	Aliquippa, PA	Old slag pile site	X				X	
Blackheart Slag Co.	Muscatine (Montpelier), IA	IPSCO Steel, Inc.						X
Buffalo Crushed Stone, Inc.	Woodlawn, NY	Old slag pile site	X					
C.J. Lagenfelder (Maryland Slag)	Baltimore (Sparrows Point), MD	International Steel Group, Inc.	X			X		
C.J. Lagenfelder & Son	Braddock, PA	U.S. Steel/Republic Technologies				X		
Edward C. Levy Co.	Decatur (Trinity), AL	Nucor Steel Corp.						X
Do.	Peoria, IL	Keystone Steel & Wire Co.						
Do.	Butler, IN	Steel Dynamics, Inc.						X
Do.	Columbia City, IN	do.						X
Do.	Crawfordsville, IN	Nucor Steel Corp.						X
Do.	Detroit, MI (two sites)	Rouge Steel Co. (Great Lakes Steel Co.)	X		X	X		
Do.	Canton, OH	The Timken Co.						X
Do.	Huger, SC	Nucor Steel Corp.						X
Essroc Corp.	Middlebranch, OH	Miscellaneous domestic and foreign		X				
Glens Falls-Lehigh	Cementon, NY	Foreign		X				
Heckett MultiServ Co.	Birmingham, AL	Structural Metals Corp.						X
Do.	Tuscaloosa, AL	Corus Tuscaloosa						X
Do.	Armorel (Hickman), AR	Nucor Steel Corp.						X
Do.	Blytheville, AR	Nucor-Yamato Steel Co.						X
Do.	Fontana, CA	Old slag pile site	X			X		
Do.	Muscatine, IA	IPSCO Steel, Inc.						X
Do.	Wilton, IA	North Star Steel, Inc.						X
Do.	Chicago, IL	Acme Steel Co. (ISG Riverdale)						X
Do.	East Chicago, IL	Ispat-Inland Steel, Inc.				X		
Do.	Indiana Harbor, IN	International Steel Group, Inc.						X
Do.	Coalton, KY	NS Group, Inc/Newport Steel						X
Do.	Ghent, KY	Gallatin Steel Co.						X
Do.	do.	North American Stainless LP						X
Do.	Ahoskie (Cofield), NC	Nucor Steel Corp.						X
Do.	Canton, OH	Republic Engineered Products LLC						X
Do.	Mansfield, OH	AK Steel Corp.				X		
Do.	Warren, OH	WCI Steel, Inc.				X		
Do.	Butler, PA	AK Steel Corp.						X
Do.	Coatsville, PA	International Steel Group, Inc.						X
Do.	Koppel, PA	Koppel Steel Co. (NS Group, Inc.)						X
Do.	Steelton, PA	International Steel Group, Inc.						X
Do.	Midlothian, TX	TXI Chaparral Steel Co.						X
Do.	Geneva (Provo), UT	Geneva Steel Hollings Corp.	X					X
Do.	Seattle, WA	Nucor Steel Corp.						X
Holcim (US) Inc.	Gary, IN	U.S. Steel LLC		X				
Do.	Weirton, WV	Weirton Steel Corp.		X				
Do.	Birmingham (Fairfield), AL	U.S. Steel LLC		X				
International Mill Services	Axis, AL	IPSCO Steel, Inc.						X
Do.	Fort Smith, AR	Macsteel						X
Do.	Kingman, AZ	North Star Steel, Inc.						X
Do.	Pueblo, CO	Rocky Mountain Steel Mills						X
Do.	Claymont, DE	Citisteel USA, Inc.						X
Do.	Cartersville, GA	Birmingham Steel Corp.						X
Do.	Chicago, IL	Calumet Steel Co.	X					X
Do.	Kankakee, IL	Birmingham Steel Corp.						X
Do.	Laplace, LA	Bayou Steel Co.						X
Do.	Jackson, MI	Macsteel						X
Do.	Monroe, MI	North Star Steel, Inc.						X
Do.	St. Paul, MN	do.						X
Do.	Jackson, MS	Birmingham Steel Corp.						X
Do.	Charlotte, NC	AmeriSteel Corp.						X
Do.	Perth Amboy, NJ	AmeriSteel Corp. (Raritan River Steel)						X
Do.	Sayreville, NJ	AmeriSteel Corp. (ex-Co-Steel)						X

See footnotes at end of table.

TABLE 3--Continued
PROCESSORS OF IRON AND STEEL SLAG IN THE UNITED STATES IN 2002

Slag processing company	Plant location	Steel company serviced[2, 3]	Slag and furnace types[1]					
			Blast furnace slag			Steel furnace slag		
			AC	GG	Exp	BOF	OHF	EAF
International Mill Services--Continued	Auburn, NY	Nucor Steel Corp.						X
Do.	Marion, OH	Marion Steel Co.						X
Do.	McMinnville, OR	Cascade Steel Rolling Mills, Inc.						X
Do.	Oregon, PA	Oregon Steel Mill, Inc.						X
Do.	Bethlehem, PA	Old slag pile site	X		X	X		
Do.	Brideville, PA	Universal Stainless & Alloy Products Inc.						X
Do.	Johnstown, PA	Old slag pile site						X
Do.	Midland, PA	J&L Specialty Products, Inc.						X
Do.	Monroeville, PA	Old slag pile site						X
Do.	New Castle, PA	Ellwood Quality Steels, Inc.						X
Do.	Park Hill, PA	Old slag pile site				X		
Do.	Pricedale, PA	do.				X		
Do.	Reading, PA	Carpenter Technology Corp.						X
Do.	Darlington, SC	Nucor Steel Corp.						X
Do.	Georgetown, SC	Georgetown Steel Corp.						X
Do.	Jackson, TN	AmeriSteel Corp.						X
Do.	Beaumont, TX	North Star Steel, Inc.						X
Do.	El Paso, TX	Border Steel, Inc.						X
Do.	Jewett, TX	Nucor Steel Corp.						X
Do.	Longview, TX	LeTourneau Steel Group						X
Do.	Plymouth, UT	Nucor Steel Corp.						X
Do.	Saukville, WI	Charter Steel						X
Do.	Weirton, WV	Weirton Steel Corp.				X		
Lafarge Corp.	Tampa, FL	Foreign		X				
Do.	Sparrows Point, MD	International Steel Group, Inc.		X				
Do.	Joppa, IL	Ispat-Inland Steel, Inc.		X				
Do.	South Chicago, IL	do.		X	X			
Do.	Lordstown, OH	Old slag pile site		X				
Do.	McDonald, OH	Youngstown Sheet and Tube Co.	X					
Do.	Warren, OH	WCI Steel, Inc.	X					
Do.	Salt Springs, OH	Youngstown Sheet and Tube Co.	X					
Do.	West Mifflin, PA	U.S. Steel LLC (ET Works)	X					
Do.	West Mifflin (Brown Reserve), PA	Old slag pile site	X					
Do.	Whitehall, PA	Foreign		X				
Do.	Seattle, WA	do.		X				
Do.	Weirton, WV	Weirton Steel Corp.	X					
Lehigh Cement	Evansville, PA	Foreign		X				
Levy Co., Inc., The	Burns Harbor, IN	International Steel Group, Inc.	X			X		
Do.	East Chicago, IN	do.	X					
Do.	Gary, IN	U.S. Steel LLC (ET Works)	X	X				
Lone Star Inc.	New Orleans, LA	Foreign		X				
Maryland Slag Co. (Lagenfelder)	Baltimore, MD	International Steel Group, Inc.	X			X		
Olympic Mill Services Inc.	Birmingham, AL	Birmingham Steel Corp.						X
Do.	Newport, AR	Arkansas Steel Assoc.						X
Do.	Rancho Cucamonga, CA	TAMCO						X
Do.	Portage, IN	Beta Steel Corp.						X
Do.	Norfolk, NE	Nucor Steel Corp.						X
Do.	Middletown, OH	AK Steel Corp.	X			X		
Do.	Mingo Junction, OH	Wheeling Pittsburgh Steel Corp.	X			X		
Do.	Youngstown, OH	V&M Star (North Star), Inc.						X
Do.	Sand Springs, OK	Sheffield Steel Corp.						X
Do.	Cayce, SC	CMC Steel Group						X
Do.	Seguin, TX	do.						X
Do.	Knoxville, TN	AmeriSteel Corp.						X
Do.	Petersburg, VA	TXI Chaparral Steel Co.						X
Rinker Materials Corp.	Miami, FL	Foreign		X				
St. Marys Cement	Detroit, MI	do.		X				
Stein, Inc.	Sterling, IL	Northwestern Steel & Wire Co.						X
Do.	Ashland, KY	AK Steel Corp.	X			X		
Do.	Cleveland, OH	International Steel Group, Inc.				X		

See footnotes at end of table.

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			AC	GG	Exp	BOF	OHF	EAF
Stein, Inc.--Continued	Loraine, OH	Republic Engineered Products LLC	X	X				
St. Lawrence Cement	Camden, NJ	Foreign		X				
Tarmac America Inc.	Medley, FL	do.		X				
Vulcan Materials Co.	Fairfield, AL	U.S. Steel LLC	X			X		
Do.	Trinity, AL	Trico Steel Co.						X

[1]Blast furnace slag type abbreviations: AC--air-cooled; GG--granulated; Exp--expanded. Steel furnace slage types: BOF--basic oxygen furnace; OHF--open hearth furnace; EAF--electric arc furnace.

[2]"Foreign" refers to the fact that the facility imports unground granulated blast furnace slag and grinds it onsite to make ground granulated blast furnace slag, commonly now referred to as "slag cement."

[3]Currently operating iron and/or steel company.